

DARPA-EA-25-02-05
Methodological Advancements for Generalizable Insights into Complex Systems
(MAGICS)

I. ARC Opportunity

The Defense Advanced Research Projects Agency (DARPA) Defense Sciences Office (DSO) is issuing an Advanced Research Concepts (ARC) Opportunity, inviting submissions of Abstracts for innovative exploratory research concepts in the technical domain of computational science research in complex, dynamic, evolving systems. This ARC Opportunity, Methodological Advancements for Generalizable Insights into Complex Systems (MAGICS), is issued under the master ARC Exploration Announcement (EA), DARPA-EA-25-02.

ARC Opportunities are designed to allow an individual researcher the opportunity and time to focus on nascent, paradigm-shifting ideas for national security applications. While multiple researchers from the same organization may propose, the aggregate level of effort for a proposed research concept is expected to be equivalent to one full-time equivalent (FTE) and 12 months, as ARC topics are designed for ideas that nominally would take a full year effort (1 FTE over 1 year) to properly validate. DARPA expects that the individual(s) working on the proposed idea primarily focus on the effort for the entire period of performance to the maximum extent practical. The maximum period of performance is 12 months. Each ARC award's total cost should range from \$100,000 to \$300,000, including direct and indirect costs and graduate student tuition, if applicable. Proposed costs for materials, equipment, and Other Direct Costs (ODC) are limited as outlined in the master ARC EA, DARPA-EA-25-02. Under no circumstances will profit be authorized. While resource sharing is not expected, it may be offered in the proposal. DARPA understands not all ideas and organizations may fit in this parameter range and will work with a proposer to ensure truly innovative ideas can be explored with the required resources. Travel and publication costs may not be proposed. No sub-awardees are permitted.

To view the original DARPA Exploration Announcement and the latest amendment issued against Advanced Research Concepts, visit SAM.gov under solicitation number DARPA-EA-25-02: <https://sam.gov/opp/95c31b3f3e094627a9a1e053766e46e1/view>. It is incumbent upon the proposer to review DARPA-EA-25-02, any resulting amendments to DARPA-EA-25-02, and Frequently Asked Questions (FAQs) before preparing and submitting an Abstract and/or an Oral Proposal Package (OPP) (if invited). All Abstract submissions to this announcement must adhere to the instructions contained in DARPA EA-25-02.

All technical, contractual, and administrative questions regarding this notice must be emailed to MAGICS@darpa.mil. This ARC Opportunity is soliciting Abstracts only. DARPA will evaluate Abstracts submitted in response to this ARC Opportunity, as detailed in Section 4 of the latest amendment issued against DARPA-EA-25-02. If the Government selects an Abstract for an Oral Presentation, the Government will issue an invitation to submit an OPP. The invitation will include the submission instructions and deadline.

All awards made as a result of the ARC Opportunity will be Research Other Transactions (OTs) awarded under the authority of 10 U.S.C. § 4021.

Abstracts submitted to this ARC Opportunity will be evaluated on a rolling basis in accordance with the latest amendment issued against DARPA-EA-25-02. The end of the submission period will be 4:00 p.m. Eastern Time on July 10, 2025. No Abstracts will be accepted after the end of the submission period. Proposers are encouraged to submit Abstracts as early as possible. Funding

for this ARC Opportunity is limited. Should funding be exhausted, the Government may elect to shorten the overall submission period with an amendment to this ARC Opportunity.

II. ARC Opportunity Description

For the past decade or more, there has been an assumption and hope that the explosion of digital data streams (e.g., social media, purchase patterns, traffic dynamics, etc.) combined with powerful machine learning tools would usher in a new era of research in complex, dynamic, evolving systems. It was widely thought that this powerful combination would enable better understanding of how large-scale systems respond to changes - such as how regional economies adapt to new conditions, or how population-level dynamics shift in response to demographic changes. Despite many attempts, results have failed to meet expectations. Progress has stalled because current statistical methods cannot create models that remain valid when applied to evolving, open, time varying, recursive, reactive, non-ergodic systems. The limitations of current methods for modeling human systems have revealed fundamental constraints on the ability to model and forecast human behavior in complex systems, and addressing these challenges requires overcoming several significant challenges that large data sets and ML do not address. A partial list includes: unstable mappings between latent constructs and observable data, insufficient methods to apply ideographically derived principles to aggregate behavior in non-ergodic systems, uncertainty in determining optimal sampling strategies, and lack of metatheoretical frameworks to support flexible application of relevant theories across contexts and domains of behavior. This list is not exhaustive, and it is likely that other challenges will also play a critical role in understanding human behavior in open systems. These must be identified and addressed to improve our ability to anticipate human behavior.

Addressing these gaps requires entirely new thinking about how to derive meaning from given sociotechnical data sets, including new techniques, theoretical insights, and understanding of the fundamental limits of inference possible from available data. By enabling researchers to systematically evaluate the applicability of methods to new contexts, we can enhance the reliability, replicability, and real-world applicability of behavioral predictions.

This ARC opportunity is soliciting ideas to explore the question: *Are there new methods and paradigms for modeling collective human behavior capable of overcoming limits of statistical approaches to accurately predict complex social phenomena and capture the dynamics of evolving, open, time varying, recursive, reactive, non-ergodic systems?*

A. ARC Opportunity Technical Objective

The MAGICS ARC calls for paradigm-shifting approaches for modeling complex, dynamic systems for predicting collective human behavior. Addressing this challenge will require the design of entirely new methodologies, metrics, tools and theoretical frameworks that can more accurately and reliably forecast human behavior by addressing the limitations and complexities that current methods struggle to capture.

Areas of interest include:

1. Data inference boundaries and limitations

There is a lack of systematic methods to determine the limits of inference for a given source of data, making it unclear how the granularity and sparsity of data relates to the predictive precision it can support, and hindering the ability to establish boundaries or what can be reliably inferred from the data.

2. Alignment validation limitations

There is a lack of effective methods to quantify the alignment between observable indicators and latent constructs, hindering model validity across different settings, populations, and time spans.¹

3. Adaptation limitations and model obsolescence

Models fail to generalize across contexts due to unclear patterns of evolution, degradation, or strengthening of underlying relationships; this failure limits the ability to assess the extent to which generalization is possible.² Additionally, models fail to account for changing conditions or new information, further resulting in decreased predictive performance.

4. Psychosocial domain limitations

Current methods lack integration across multiple psychological theories, limiting their applicability to particular constructs, populations and contexts. These siloed approaches hinder the understanding of complex interrelationships among latent variables, from attitude formation, to identity development.³

5. Complex phenomena

Current methods struggle to capture the complexity and reflexivity of social phenomena (i.e., systems often change as a result of being studied), highlighting the need for new approaches to better understand and model highly complex systems.^{4 5}

Whether addressing an above limitation or another limitation inherent to the MAGICS question, proposers must work with open-world systems and data sets; toy problems or constrained and simulated systems are out of scope. Proposers must also articulate a plan to assess the validity of resulting predictions against ground truth, ideally with forward models, rather than hind-casting.

Proposals that incorporate theoretical, computational, and empirical efforts by integrating disciplines such as psychometrics, behavioral science, data science, and machine learning are within scope. Approaches that focus solely on one facet—e.g., refining a single psychometric scale without addressing generalizability—are out of scope. Additionally, approaches that result in models that lack a clear and meaningful connection to the underlying phenomena are also out of scope.

Ultimately, the goal is to spur the development of novel, rigorous methods and frameworks that advance our collective capacity to understand and predict human behavior with greater accuracy and nuance.

¹ Flake, J. K., & Fried, E. I. (2020). Measurement Schmeasurement: Questionable Measurement Practices and How to Avoid Them. *Advances in Methods and Practices in Psychological Science*, 3(4), 456-465. <https://doi.org/10.1177/2515245920952393>.

² Bornstein, M. H., Putnick, D. L., & Lansford, J. E. (2021). Standing the test of time: Introduction to the special section on measurement invariance. *Developmental Psychology*, 57(2), 155–161. <https://doi.org/10.1037/dev0001141>.

³ Hardin, E. E., & Robitschek, C. (2019). The healing power of measuring well: A call for rigorous construct measurement. *The Counseling Psychologist*, 47(7), 1069–1086. <https://doi.org/10.1177/0011000019878803>.

⁴ Fan, Y., Lehmann, S., & Blok, A. (2023). New methodologies for the digital age? How methods (re-) organize research using social media data. *Quantitative Science Studies*, 4(4), 976-996.

⁵ Pothos, E. M., & Busemeyer, J. R. (2022). Quantum cognition, *Annual Review of Psychology*, 73(1), 749-778.

B. ARC Abstracts

MAGICS ARC Abstracts should clearly articulate an approach to design a systematic method that identifies the limits or boundaries of inference from a data source(s) in understanding social systems and the psychological domain across multiple phenomena.

Abstracts should quantitatively define the current state-of-the-art classical solution to the proposer's target problem. Understanding the potential impact of a new method requires a clear understanding of the existing alternatives as they are applied to social systems and the psychological domain. Specific details should be provided on the chosen problem of interest rather than a general topic overview

MAGICS ARC abstract submissions must provide a substantial technical argument that their proposed approach has the potential to significantly advance the current state-of-the-art in modeling human behavior in complex, dynamic systems. This includes:

- **Clearly articulated problem:** Abstracts should precisely define the specific problem within the scope of MAGICS that the proposed approach aims to address. This requires moving beyond general topic overviews to provide concrete details about the chosen problem area (e.g., data inference boundaries, alignment validation limitations, adaptation limitations, psychosocial domain limitations, complex phenomena). Proposals must detail a systematic method for identifying the limits or boundaries of inference from data sources relevant to understanding social systems and the psychological domain.
- **Quantitative benchmarking against existing methods:** Abstracts must quantitatively define the current state-of-the-art classical solution to the targeted problem. A clear and quantitative understanding of existing methods and their limitations, specifically as applied to social systems and/or the psychological domain, is essential for evaluating the potential impact of any proposed new method.
- **Novelty and advancement:** Abstracts should clearly articulate how the proposed approach addresses the limitations of existing methods and offers a significant advancement over the current state-of-the-art.
- **Evaluation plan:** Abstracts should outline a plan to demonstrate the predictive validity of the proposed approach against ground truth data. This should include a description of proposed data and plan for data acquisition and management, including protection against the improper use or disclosure of PII, PAI, and CAI (Personally Identifiable Information, Publicly Available Information, and Commercially Available Information).

Additionally, abstracts should include a detailed research plan outlining:

- **Intermediate technical objectives:** Clearly defined, measurable objectives that represent significant steps towards achieving the overall research goal.
- **Evaluation measures:** Specific and quantifiable metrics for evaluating the success of each technical objective.
- **Schedule and deliverables:** A timeline, segmented monthly outlining anticipated deliverables aligned with the research objectives.

Proposers must give careful consideration to, and justify, their choices of data, including acknowledging systematic error, limitations to sampling accuracy, and other characteristics relevant to understanding the limits of inference.

This ARC Opportunity is intended to be as inclusive as possible; however, proposed ideas should

address the appropriate scope, have a clear deliverable at the end of the effort, and include specific practical applications of the research.

We highly encourage submitters with or without prior Department of Defense related research experience to apply for this opportunity.

DARPA will evaluate Abstracts submitted in response to this ARC Opportunity, as detailed in Section 4 of the latest amendment issued against DARPA-EA-25-02. If the Government selects an Abstract for an Oral Presentation, the Government will issue an invitation to submit an OPP. The invitation will include the submission instructions and deadline.

C. Schedule of Milestones

The specific milestones and due dates listed below are common to all Abstracts and OPPs (see above for technical details and Section III.A. below for additional information on milestones). Abstracts selected to submit an OPP will be required to propose milestones associated with the program plan as part of the oral proposal.

- Kick-off meeting (within first month after award): The first milestone should consist of a kick-off meeting to define the technical approach and steps forward.
- Milestone status meetings (monthly): These meetings will include detailed progress reports on all research objectives, including challenges encountered, risk mitigation strategies, and adjustments to the research plan as needed. These meetings will also include discussion of upcoming milestones and ensure alignment with program goals.
- Validation plan (no later than month 2): Detailed validation plan, including description, acquisition plan, and justification for the ground truth data, and description of the metrics and benchmarks to be used to measure performance.
- Final milestone meeting and report (one month prior to award end date): The final briefing and final report should summarize all work completed on the project, highlighting accomplishments, lessons learned, unexpected outcomes, and challenges requiring further research.

D. Reporting Requirements

Performers will be expected to provide at a minimum the following reports:

- Monthly update reports. These technical reports should include progress to plan including detailed progress on all research objectives, including challenges encountered, risk mitigation strategies, and adjustments to the research plan as needed.
- Milestone technical report. Each report should detail progress towards specific milestone objectives associated explanatory presentation slides, algorithms, validation progress and results, publications, and software source code with full documentation, as applicable. Each milestone report should include a master document that refers to all research objectives and builds on the previous milestone submission.
- Final technical report. The final report should include the final master document from the Milestone technical reports and detail results of all milestones associated with the program plan for the entire period of performance. The report and outbrief should include a thorough presentation of validation results, including performance across all relevant metrics, comparison to existing methods, and analysis of strengths and limitations, and a discussion of the implications of the validation findings.

III. ARC Opportunity Submission Format, Instructions and Selection

A. Abstract Content and Format

All Abstracts submitted in response to this notice must comply with the content and format instructions in Section 3.1 of the latest amendment issued against DARPA-EA-25-02. The submission must use the template provided as attachment to DARPA-EA-25-02. Abstracts submitted in response to this ARC Opportunity must be unclassified.

B. Abstract and OPP Submission Instructions

Abstracts submitted in response to this ARC Opportunity and OPPs submitted in response to an invitation shall be submitted electronically via the DARPA Submission website at <https://baa.darpa.mil>. See Section 3.3 of the latest amendment issued against DARPA-EA-25-02 for Abstract and OPP submission instructions.

Technical support for the DARPA Submission website is available during regular business hours, Monday – Friday, 9:00 a.m. – 5:00 p.m. Eastern Time. Requests for technical support must be emailed to BAAT_Support@darpa.mil with a copy to MAGICS@darpa.mil. Questions regarding submission contents, format, deadlines, etc. should be emailed to MAGICS@darpa.mil. Questions/requests for support sent to any other email address may result in delayed/no response.

DARPA will acknowledge receipt of complete submissions via email and assign identifying numbers that should be used in all further correspondence regarding those submissions. If no confirmation is received within two (2) business days, please contact MAGICS@darpa.mil to verify receipt.

No Abstracts will be accepted after the end of the overall submission period listed in Section I above. Abstracts must be submitted per the instructions outlined in this ARC Opportunity *and received by DARPA* no later than this time and date. Proposers are advised that the Abstract submission deadline outlined herein is in Eastern Time.

Abstracts will be evaluated and selected in accordance with Section 4 of the latest amendment issued against DARPA-EA-25-02.

IV. Award Information

Selected OPPs will result in a potential award of a Research OT agreement subject to the proposer's acceptance of the terms and conditions. Proposers must review the model Research OT agreement provided as Attachment E to DARPA-EA-25-02.

The completed Task Description Document, Schedule of Milestones and Payments (templates included in Attachment I), and data rights will be included in the Research OT agreement upon award.

Given the limited funding available for each ARC Opportunity, not all proposals considered selectable may be selected for a potential award.

V. Eligibility

See Section 7.2 of the latest amendment issued against DARPA-EA-25-02 for information on who may be eligible to respond to this notice.

VI. Human Subject Research

Abstracts to this ARC Opportunity proposing new human subjects research will be considered out of scope and may be disregarded.

VII. Administrative Requirements

Section 7.2 of the latest amendment issued against DARPA-EA-25-02 provides information on administrative requirements that may be applicable for proposal submission as well as performance under an award.

VIII. Frequently Asked Questions (FAQs)

All technical, contractual, and administrative questions regarding this notice must be emailed to MAGICS@darpa.mil. Emails sent directly to the ARC Manager or any other address may result in delayed or no response.

All questions must be in English and must include the name, email address, and telephone number of a point of contact. DARPA will attempt to answer questions publicly in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered.

DARPA may post an FAQ list under the MAGICS Opportunity on the DARPA/DSO Opportunities page at (<http://www.darpa.mil/work-with-us/opportunities>). The list will be updated on an ongoing basis until one (1) week prior to the abstract due date. DARPA will also maintain <https://www.darpa.mil/ARC> as a resource page with links to all relevant ARC Opportunities and FAQs.